# PATENT ABSTRACTS OF JAPAN

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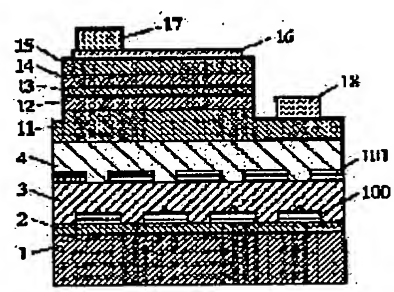
## (54) NITRIDE SEMICONDUCTOR LIGHT-RECEIVING ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To realize a laser element of a structure, wherein light which leaks mainly in the side of a substrate is effectively made to reflect to improve the light extraction efficiency of a light-emitting element and at the same time, effective reflecting mirrors, which are used as resonators, are provided in the interior of a semiconductor layer.




SOLUTION: First, reflecting mirrors 100, which are not grown with a nitride semiconductor film on the surfaces thereof or have a property to hardly grow the nitride semiconductor film on the surfaces thereof and make light emission from an active layer reflect, are partially formed on a base layer consisting of a first nitride semiconductor layer 2 formed on a heterosubstrate 1, consisting of a material different from a nitride semiconductor material. Moreover, a second nitride semiconductor layer 3 grown in such a way that the layer 3 reaches from the window parts of the mirrors 100 to the surface of the mirrors 100 is used as a substrate, and a plurality of nitride semiconductor layers including at least the active layer are laminated on the substrate, whereby the light emission from the active layer is made to be reflected upwards by the mirrors 100.

## LEGAL STATUS

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## CLAIMS

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[Claim(s)]
[Claim 1] On the ground layer which consists of the 1st nitride semiconductor formed on the different-species substrate which consists of a different material from a nitride semiconductor Or it has the property to be hard to grow up. or [ that a nitride semiconductor does not grow up to be a front face ] -- And the 1st reflecting mirror which reflects luminescence of a barrier layer is formed partially, and the 2nd nitride semiconductor which grew so that the front face of the reflecting mirror might be reached is further used as a substrate from the window part of the 1st reflecting mirror. The nitride semiconductor light emitting device to which the laminating of two or more nitride semiconductor layers which contain a barrier layer at least on the substrate is carried out, and they are characterized by the bird clapper.
[Claim 2] The nitride semiconductor light emitting device according to claim 1 which the 2nd reflecting mirror is partially formed on the nitride semiconductor layer of the above 2nd, and two or more nitride semiconductor layers which contain a barrier layer at least on the substrate grow by using as a substrate the 3rd nitride semiconductor which grew from the window part of the 2nd reflecting mirror so that the front face of the 2nd reflecting mirror might be reached, and is characterized by the bird clapper.
[Claim 3] The 2nd reflecting mirror of the above is a nitride semiconductor light emitting device according to claim 2 characterized by being formed on the 2nd nitride semiconductor layer corresponding to the position of the window part of the 1st reflecting mirror.
[Claim 4] The nitride semiconductor light emitting device according to claim 1 to which area of the aforementioned reflecting mirror is characterized by being larger than the area of a window part.

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[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the light emitting device which consists of a nitride semiconductor (InaAlbGa1-a-bN, 0<=a, 0<=b, a+b<=1) used for light emitting diode (Light Emitting Diode), a laser diode (LD), a super luminescent diode (SLD), etc.
[0002]
[Description of the Prior Art] The nitride semiconductor is already put in practical use as blue Light Emitting Diode and a green Light Emitting Diode. These Light Emitting Diodes have terrorism structure to the double by which the laminating of n type and the p type nitride semiconductor was carried out on silicon on sapphire, and the barrier layer has the nitride semiconductor layer of quantum well structure. The nitride semiconductor light emitting device which constitutes Light Emitting Diode is divided into two kinds of modes, the case where this silicon-on-sapphire side is made into a luminescence observation side side, and when a nitride semiconductor layer side is made into a luminescence observation side side. Since the chip size became large, and it generally uses the property of transparent sapphire positively although handling nature also has the fault which becomes bad in case an electrode is connected to a base material like a leadframe since positive and the negative electrode are prepared in the same side side when a nitride semiconductor makes a silicon-on-sapphire side a luminescence observation side for example, there is an advantage that optical ejection efficiency becomes good. On the other hand, although a chip size can also be made small and handling nature is also very excellent compared with the case of the former when making a nitride semiconductor side into a luminescence observation side, the light which leaks to a silicon-on-sapphire side has the fault that it is absorbed by the adhesives of a leadframe and optical ejection efficiency becomes bad. The direction of the latter with handling nature sufficient [ Light Emitting Diode generally marketed ] is chosen.
[0003]
[Problem(s) to be Solved by the Invention] Although the technology which forms a light reflex film in a silicon-on-sapphire front face was also proposed in order to reflect the light which leaks to a silicon-on-sapphire side in the case of the latter, it was not what it can still be satisfied [ with this technology ] of enough. Moreover, in the technology which forms a reflecting mirror in the interior of a semiconductor layer like a surface emission-type laser element, when a reflecting mirror is prepared in a silicon-on-sapphire side, it is in a difficult inclination that distance with a barrier layer is too large, and uses a reflecting mirror as a resonator.
[0004] It is in realizing the laser element which has the effective reflecting mirror which this invention is made in view of such a situation, and the place made into the purpose makes reflect effectively the light which leaks mainly to a substrate side, and is to raise the optical ejection efficiency of a light emitting device, and serves as a resonator inside a semiconductor layer.
[0005]
[Means for Solving the Problem] The light emitting device of this invention on the ground layer which consists of the 1st nitride semiconductor formed on the different-species substrate which consists of a different material from a nitride semiconductor Or it has the property to be hard to

grow up. or [ that a nitride semiconductor does not grow up to be a front face ] -- And the 1st reflecting mirror which reflects luminescence of a barrier layer is formed partially, and the 2nd nitride semiconductor which grew so that the front face of the reflecting mirror might be reached is further used as a substrate from the window part of the 1st reflecting mirror. The laminating of two or more nitride semiconductor layers which contain a barrier layer at least on the substrate is carried out, and they are characterized by the bird clapper.

[0006] Furthermore, the 2nd reflecting mirror is partially formed on the nitride semiconductor layer of the above 2nd, from the window part of the 2nd reflecting mirror, by using as a substrate the 3rd nitride semiconductor which grew so that the front face of the 2nd reflecting mirror might be reached, two or more nitride semiconductor layers which contain a barrier layer at least on the substrate grow, and the light emitting device of this invention is characterized by the bird clapper.

[0007] As for the 2nd reflecting mirror of the above, it is desirable to be formed on the 2nd nitride semiconductor layer corresponding to the position of the window part of the 1st reflecting mirror. In addition, in this invention, you may grow up the semiconductor layer which consists of material which a different-species substrate, the 1st reflecting mirror, a ground layer, the nitride semiconductor layer containing the barrier layer above the 2nd nitride semiconductor, and the 2nd nitride semiconductor touch, and do not necessarily need to be formed, for example, is different from a nitride semiconductor among them.

[0008] Moreover, in the light emitting device of this invention, area of the aforementioned reflecting mirror is characterized by being larger than the area of a window part.

[0009]

[Embodiments of the Invention] Drawing 1 is the typical cross section showing the structure of the nitride semiconductor wafer obtained in each process until it grows up the 2nd nitride semiconductor layer from a different-species substrate in the light emitting device of this invention.

[0010] In order to grow up the substrate which consists of the 2nd nitride semiconductor 3, as first shown in drawing 1 (a), on the different-species substrate 1, the ground layer 2 which consists of the 1st nitride semiconductor is grown up, and the 1st reflecting mirror 100 is partially formed on the ground layer 2. The different-species substrate 1 consists of a different material from the nitride semiconductor proposed conventionally, and the material with which a nitride semiconductor can grow up to be the front face through a buffer layer is chosen. The oxide system substrate which carries out grid adjustment also in it with a spinel (MgAl 2O4) besides the sapphire put in practical use, ZnO, GaAs, Si and SiC, and a nitride semiconductor is proposed.

[0011] The ground layer 2 can grow in 200 degrees C - 900 degrees C low temperature through the buffer layer which consists of AlXGa1-XN (0<=X<=1) by growing up a nitride semiconductor at an elevated temperature rather than the buffer layer. In this invention, it is called a ground layer including a nitride semiconductor including the buffer layer. That is, the ground layer may consist of two or more nitride semiconductor layers. However, in order that a ground layer may grow on a different-species substrate, according to factors, such as a coefficient-of-thermal-expansion difference of a different-species substrate and a ground layer, and grid mismatching, it has very many crystal defects, for example, has 109 more than [/cm / 2 ] penetration dislocation, and does not serve as a nitride semiconductor substrate. As most desirable ground layer, undoping or n type high impurity concentration grows up three or less 1x1017-/cm GaN through a buffer layer. In addition, the buffer layer which consists of nitride semiconductors, such as ZnO, and a different semiconductor between a ground layer and a different-species substrate can also be grown up.

[0012] The 1st reflecting mirror 100 formed on the ground layer 2 has the operation which lessens the crystal def ct of the 2nd nitride semiconductor layer which grows up to be a longitudinal direction so that the front face of a reflecting mirror may be reached [ from the window part of a refl cting mirror ] while having the operation which reflects luminescence of a barrier layer in the upper part. A reflecting mirror is preferably formed in the shape of a stripe, although what configuration is sufficient as long as it forms partially on a shape of shape for

example, of stripe, and dot, in-a-grid-pattern **, and ground layer. or [ that a nitride semiconductor does not grow up to be the front face of the reflecting mirror as a material of a reflecting mirror ] -- or if it is the material which has the property to be hard to grow up and is the material which reflects luminescence of a barrier layer in a barrier-layer side, the multilayer which what material is sufficient as, for example, consists of the dielectric of SiO2, SixNy, TiO2, TixNy, and ZrO2 grade can be chosen It acts as a reflecting mirror by carrying out the laminating of these dielectrics so that it may be set to lambda/4n (lambda:luminescence wavelength, refractive index of n:dielectric). Moreover, the metal which has the property in which luminescence of a barrier layer is reflected with the metal of silver white, and a nitride semiconductor cannot grow up to be a front face easily like Pt, nickel, Cr, and Ag is sufficient. In addition, as for a reflecting mirror, it is desirable to choose the material which has the melting point to which a dielectric multilayer, a metal, etc. bear the growth temperature of the 2nd nitride semiconductor.

[0013] Although the 1st reflecting mirror 100 is formed on the ground layer which consists of the 1st nitride semiconductor which grew on the different-species substrate 1 as shown in drawing 1 , it can also be directly formed on the different-species substrate 1. For example, when sapphire is used for the different-species substrate 1, it is desirable to grow up the 1st nitride semiconductor 2 on sapphire when growing up the 2nd nitride semiconductor 3 with more few crystal defects. On the other hand, when using for a substrate the substrate which carried out grid adjustment with the nitride semiconductor, and a substrate with a near lattice constant, it is also possible to form the 1st reflecting mirror 100 in contact with a different-species substrate directly.

[0014] Next, as shown in drawing 1 (b), the 2nd nitride semiconductor 3 is grown up from the window part of the ground layer in which the aforementioned reflecting mirror was formed. Since the reflecting mirror 100 has the property in which a nitride semiconductor cannot grow up to be a front face easily, as the 2nd nitride semiconductor 3 grows from a window part and is shown in a broth and (b), it grows up to be a longitudinal direction in the upper part of the 1st reflecting mirror 100. If growth is furthermore continued, as shown in drawing 1 (c), the 2nd nitride semiconductor which grows up to be a longitudinal direction and lengthwise will be about connected in the upper part of a reflecting mirror center section, and will serve as a nitride semiconductor substrate. When the 2nd nitride semiconductor 3 is grown up, the crystal defect of the 2nd nitride semiconductor which grows up to be a longitudinal direction stops thus, extending from a ground layer by covering the crystal defect of the ground layer 2 with the reflecting mirror. Moreover, as the crystal defect extended from a window part is the 2nd nitride semiconductor layer, in order to stop, after the 2nd nitride semiconductor layer growth, the crystal defect which appears in a front face decreases very much, for example, becomes 2 or less [ 108 //cm ] and 2 or less [ 107 more //cm ]. The 2nd nitride semiconductor 3 is the most desirable when it produces a crystalline good substrate that undoping or n type high impurity concentration grows up three or less 1x1017-/cm GaN.

[0015] As a still more desirable mode, as shown in drawing 1 (d), the 2nd reflecting mirror 101 as well as [ still ] the 1st reflecting mirror is formed on the 2nd nitride semiconductor layer, and the 3rd nitride semiconductor layer 4 is similarly grown up into the upper part of this 2nd reflecting mirror 101. By forming the 2nd reflecting mirror 101, the crystal defect of the 3rd nitride semiconductor 4 grown up into the upper part of the 2nd reflecting mirror decreases further. That is because there are few crystal defects of the 2nd nitride semiconductor layer 3 used as a ground. As preferably shown in (d), it sees superficially from a nitride semiconductor layer side by forming the position of the 2nd reflecting mirror 101 in the front face of the 2nd nitride semiconductor layer 3 corresponding to the window part of the 1st reflecting mirror, and since it becomes the form where all were covered with the reflecting mirror, optical ejection efficiency improves further. Moreover, when the crystal defect of the 2nd nitride semiconductor 3 has appeared in the window part, for example, for a wrap reason, the crystal defect of the 3rd nitride semiconductor layer which grows up to be a longitudinal direction on the 2nd reflecting mirror decreases the window part further with the 2nd reflecting mirror. That is, as for the 2nd reflecting mirror 101, it is most desirable to form on the 1st nitride semiconductor layer 3 to

which the crystal defect has appeared in the front face. However, you may form the 3rd reflecting mirror at random.

[0016] The operation of the reflecting mirror of this invention is as follows. The nitride semiconductor layer which grew from th window part of a reflecting mirror and grew up to be a longitudinal direction on the surface of the reflecting mirror has very few crystal defects. Therefore, the crystal defect of two or more nitride semiconductor layers containing the barrier layer grown up on the substrate decreases like a nitride semiconductor substrate by using the nitride semiconductor as a substrate. Therefore, an element becomes long lasting, in order that a crystal defect may not carry out dislocation to a barrier layer, when a light emitting device is produced. Moreover, it improves in all fields, such as pressure-proofing of an opposite direction, and the current characteristic of a leakage current. And for a certain reason, the light of the operation which reflects luminescence of a barrier layer in a barrier-layer side which leaks to a substrate side decreases, and optical ejection efficiency of a reflecting mirror improves in the light emitting device which makes a semiconductor side a luminescence observation side. Therefore, while the reflective section becomes large and optical ejection efficiency improves by making area of a reflecting mirror larger than the area of a window part, the number of the crystal defects extended from a window part also decreases, and a still more desirable light emitting device can be realized. As stated also in advance preferably, since it becomes the form where the reflecting mirror was wearing all the fields substantially on the flat surface, by arranging a reflecting mirror in two or more stages lengthwise, optical ejection efficiency improves further. Moreover, in the case of a laser element, since it acts as a resonator, a surface emission-type laser element is realizable [ the 1st reflecting mirror 100 or the 2nd reflecting mirror 101 is in the interior of a semiconductor layer, distance of while with a barrier layer is near, and ] with a nitride semiconductor.

[0017]

[Example] [Example 1] drawing 2 is the type section view showing the structure of the Light Emitting Diode element concerning an example 1. Based on this drawing, an example 1 is explained below. First, the MOVPE method is used on the different-species substrate 1 which consists of sapphire, and the 1st nitride semiconductor layer 2 is grown up. The 1st nitride semiconductor layer 2 consists of a buffer layer which consists of GaN which grew at 500 degrees C sequentially from a different-species substrate side, and GaN which grew at 1050 degrees C on the buffer layer.

[0018] Next, by the CVD system, all over the 1st nitride semiconductor layer 2, a wafer is picked out from a reaction container, and two or more dielectric multilayers which consist of SiO2 and SiN are formed by turns so that single thickness may be set to lambda/4n, and a dielectric multilayer is formed.

[0019] A mask is formed in the position on the dielectric multilayer after dielectric multilayer formation, selective etching of the dielectric multilayer is carried out, and it considers as stripe width of face of 10 micrometers, and the stripe interval (window part) of 2 micrometers, and considers as the 1st reflecting mirror 100. In case such 1st reflecting mirror 100 is formed by the dielectric multilayer, form a dielectric multilayer all over the 1st nitride semiconductor layer first, and selective etching of the dielectric multilayer is carried out after that. The technology made into a predetermined configuration forms a mask in the position on a nitride semiconductor layer, forms a dielectric multilayer from on the, and a dielectric multilayer tends to form it by uniform thickness compared with the method of removing a mask and leaving only a dielectric multilayer by the lift-off method after that. Moreover, since it **********s, the nitride semiconductor layer front face of a window part also tends to observe an etch pit, a crystal defect, etc. which have appeared in the front face. The same of the advantage of this technique is said of the case of th 2nd reflecting mirror 101.

[0020] Next, after forming the 1st reflecting mirror 100, a wafer is returned in a MOVPE reaction container and the 2nd nitride semiconductor layer 3 which consists of undoping GaN at 1050 degrees C is grown up by 20-micrometer thickness.

[0021] A wafer is picked out from a reaction container after the 2nd nitride semiconductor layer 3 growth, and after forming again the dielectric multilayer which consists of SiO2 and SiN all over

the 2nd nitride semiconductor layer 3 in a CVD system, from selective etching, it considers as stripe width of face of 10 micrometers, and 2 micrometers of window parts, and considers as the 2nd reflecting mirror 102. However, it forms so that the stripe of the 1st reflecting mirror 100 and the 2nd reflecting mirror 101 may become parallel, and it sees from a flat surface, and is made for the window part of the 1st reflecting mirror 100 to be closed as the formation position of the 2nd reflecting mirror 101 is shown in drawing 2 .
[0022] Next, a wafer is returned in a reaction container and the 3rd nitride semiconductor layer 4 which consists of undoping GaN at 1050 degrees C is grown up by 20-micrometer thickness.
[0023] Then, 4 micrometers of the n side contact layers 11 which consist of n type GaN which carried out Si dope at 1050 degrees C are grown up, and 0.1 micrometers of the n side clad layers 12 to which Si concentration consists of GaN fewer than the n side contact layer on it are grown up.
[0024] Next, the barrier layer 13 which consists of undoping In0.1Ga0.9N which has the single quantum well structure of 30A of thickness at 800 degrees C is grown up, 0.1 micrometers of the p side clad layers 14 which consist of Mg dope p type aluminum0.1Ga0.9N at 1050 degrees C on it are grown up, and 0.5 micrometers of the p side contact layers 15 which become the last from Mg dope p type GaN are grown up.
[0025] After picking out a wafer from a reaction container after a reaction end, performing annealing at 700 degrees C among nitrogen-gas-atmosphere mind and forming p type layer into low resistance further, as shown in drawing 2 , etching is performed from the p side contact layer 15 side, and the front face of the n side contact layer 11 is exposed. then, the front face of the p side contact layer of the best layer -- almost -- the whole surface -- ohmic one of a translucency -- the p electrode 16 of business is formed and p pad electrode 17 for bondings is formed on it On the other hand, the n electrode 18 which consists of W/aluminum is formed in the front face of the n side contact layer 18 in which the point was exposed.
[0026] After grinding silicon on sapphire and making it thin finally, when it separated into the chip of 350-micrometer angle and considered as the blue Light Emitting Diode element, as compared with the conventional Light Emitting Diode element which does not prepare a reflecting mirror, it improved 50% or more with the output, and improved several or more times from the element life. Moreover, pressure-proofing of an opposite direction also improved 50% or more as compared with the conventional thing. Since the 2nd and 3rd nitride semiconductor serves as a substrate, the crystal defect of this of the element itself decreases and it can be imagined to be that pressure-proofing of an opposite direction and whose element life improved.
[0027] [Example 2] drawing 3 is the type section view showing the structure of LD element concerning the example 2 of this invention, and specifically shows the structure of a surface emission-type laser element. Based on this drawing, an example 2 is explained below.
[0028] The laminating of the 2nd reflecting mirror 101 of the shape of a stripe which consists of a GaN buffer layer, the 1st nitride semiconductor layer 2 which consists of undoping GaN, the 1st reflecting mirror 100 of the shape of a stripe which consists of a dielectric multilayer, the 2nd nitride semiconductor layer 3 which consists of undoping GaN, and a dielectric multilayer like an example 1 on the different-species substrate 1 which consists of sapphire, and the 3rd nitride semiconductor layer 4 which consists of undoping GaN is carried out to order.
[0029] Then, after growing up 4 micrometers of the n side contact layers 21 which consist of Si dope n type GaN, the laminating of the undoping aluminum0.15Ga0.85N layer and the Si dope GaN layer of 25A of thickness of 25A of thickness is carried out by turns, and the n side clad layer 22 which consists of the superlattice of the 0.4 micrometers of the total thickness is grown up.
[0030] Next, the laminating of the well layer which consists of the barrier layer and 40A undoping In0.2Ga0.8N which consists of 40A undoping In0.01Ga0.95N is carried out by turns, finally it is finished as a barrier layer, and the barrier layer 23 of the multiplex quantum well structure (MQW) of the 440A of the total thickness is grown up.
[0031] Next, the laminating of 25A undoping aluminum0.15Ga0.85N layer and a 25A Mg dope GaN layer is carried out by turns, and the p side clad layer 24 which consists of a superlattice layer of the 0.4 micrometers of the total thickness is grown up.

[0032] A wafer is picked out from a r action container after the p side clad layer growth, and the protective coat which consists of SiO2 which has a round shape is formed in the front face of the p type clad layer. However, the position of the mask is smaller than the 2nd reflecting mirror 101 of the above, and it is formed so that it may become right above the reflecting mirror.
[0033] After protective coat formation, again, a wafer is moved in a reaction container and the current blocking layer 26 which consists of Si dope n type aluminum0.1Ga0.9N is formed in the front face of the p side clad layer 24 in which the protective coat is not formed by 0.4-micrometer thickness. in addition, p type impurity which cannot become p type easily even if this current blocking layer dopes a p type impurity like Zn and Cd -- doping -- high -- good also as an i type nitride semiconductor layer [ **** ] -- carrying out -- moreover, aluminum mixed-crystal ratio -- a clad layer -- large -- carrying out -- high -- i type AlGaN [ **** ] can also be formed
[0034] After picking out a wafer from a reaction container after current blocking-layer 26 formation and carrying out dissolution removal of the protective coat, the p side contact layer 25 which consists of Mg dope p type GaN on the current blocking layer 26 in a reaction container again is grown up.
[0035] After a reaction end, annealing is performed and p layers are further formed into low resistance. as well as an example 1 While forming the n electrode 28 in the n side contact layer 22 which was made to expose a part of n side contact layer 22 by etching, and was exposed After forming the p electrode 27 in the front face of the p side contact layer, when it considered as the laser element of structure as divided a wafer into a chip and shown in drawing 3 , continuous oscillation was shown in the room temperature and the 410nm laser beam was observed from the silicon-on-sapphire side.
[0036] [Example 3] drawing 4 is the type section view showing the structure of LD element concerning the example 3 of this invention, and this also shows the structure of a surface emission-type laser element. Based on this drawing, an example 3 is explained below.
[0037] In an example 1, in case the 2nd nitride semiconductor layer 3 is grown up after forming the 1st reflecting mirror 100 of the shape of a stripe which consists of a GaN buffer layer, the 1st nitride semiconductor layer 2 which consists of undoping GaN, and a dielectric multilayer on the different-species substrate 1 which consists of sapphire, GaN which doped Si 5x1016-/cm3 is grown up by 60-micrometer thickness. Thickness of this 2nd nitride semiconductor layer is set to 60 micrometers or more for removing a different-species substrate behind and using the 2nd nitride semiconductor layer as a substrate. When thinner than 60 micrometers, the 2nd nitride semiconductor layer breaks during different-species substrate removal, and it is in the inclination for element production to become difficult. Furthermore, the little dope of the n type impurity is carried out because the 2nd nitride semiconductor layer 3 and the very thing which are exposed are used as a contact layer after removing a different-species substrate. When doping n type impurity in the 2nd nitride semiconductor layer and the 3rd nitride semiconductor layer which furthermore serve as a substrate, it is desirable to be referred to as three or less 1x1017-/cm as stated also in advance. It is the shell which the number of the crystal defects in a nitride semiconductor layer will increase if it is made [ more ] than it, and cannot serve as a crystalline good substrate easily.
[0038] The 2nd reflecting mirror 101 is formed like an example 1 after the 2nd nitride semiconductor layer 3 growth. 15 micrometers of 3rd nitride semiconductor layer 4 which consists of undoping GaN are grown up after the 2nd reflecting mirror formation.
[0039] Next, the crack prevention layer 20 which consists of In0.05Ga0.95N which doped Si is grown up by 0.15-micrometer thickness. By using the crack prevention layer 20 as the nitride semiconductor containing In, a crack stops easily being able to go into the nitride semiconductor layer containing aluminum which this layer grows up behind by becoming a buffer coat. In addition, this crack prevention lay r cannot be overemphasized by that you may put into the laser element of an example 2.
[0040] The rest carries out the laminating of the n side clad layer 22 which consists of a superlattice, the barrier layer 23 of MQW, the p side clad layer 24 which consists of a superlattice, the current blocking layer 26, and the p side contact layer 25 like an example 2.

[0041] After a reaction end, after performing annealing and forming p layers into low resistance further, it grinds from a sapphire side and the different-species substrate 1, the 1st nitride semiconductor layer 2, and the 1st reflecting mirror 101 are removed. Then, after preparing ring-like n electrode in the front face of the 2nd exposed nitride semiconductor layer 2, the wafer was separated in the shape of a chip, when considered as the laser element of structure as shown in drawing 4 , continuous oscillation was shown in the room temperature and, similarly the 410nm laser beam was observed from the 2nd nitride semiconductor layer 3 side. In addition, in case the n electrode 28 is formed, in order to improve the ohmic contact of the electrode contact surface, technology, such as ion implantation, may be used and n type impurity may be doped on the front face of the 2nd nitride semiconductor layer at high concentration.

[0042]

[Effect of the Invention] By the light emitting device of this invention, as explained above, since the crystal defect of a nitride semiconductor layer which grew from the window part of a reflecting mirror and grew up to be a longitudinal direction on the surface of the reflecting mirror decreases very much, the crystal defect of two or more nitride semiconductor layers containing the barrier layer grown up on the substrate decreases, and the reliability of an element improves. Moreover, since a reflecting mirror reflects luminescence of a barrier layer in a barrier-layer side in a near distance of dozens of micrometers or less, the optical ejection efficiency of a light emitting device improves. Therefore, if this reflecting mirror is used positively, a surface emission-type laser element is realizable.

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[Translation done.]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The type section view showing partially the structure of the wafer for explaining each process at the time of manufacturing the light emitting device of this invention, respectively.
[Drawing 2] The type section view showing the structure of the light emitting device of an example 1.
[Drawing 3] The type section view showing the structure of the light emitting device of an example 2.
[Drawing 4] The type section view showing the structure of the light emitting device of an example 3.
[Description of Notations]
1 ... Different-species substrate
2 ... 1st nitride semiconductor layer
3 ... 2nd nitride semiconductor layer
4 ... 3rd nitride semiconductor layer
11 21 ... The n side contact layer
12 22 ... The n side clad layer
13 23 ... Barrier layer
14 24 ... The p side clad layer
15 25 ... The p side contact layer
20 ... Crack prevention layer
26 ... Current blocking layer
16 27 ... p electrode
17 ... p pad electrode
18 28 ... n electrode
100 ... The 1st reflecting mirror
101 ... The 2nd reflecting mirror

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

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DRAWINGS

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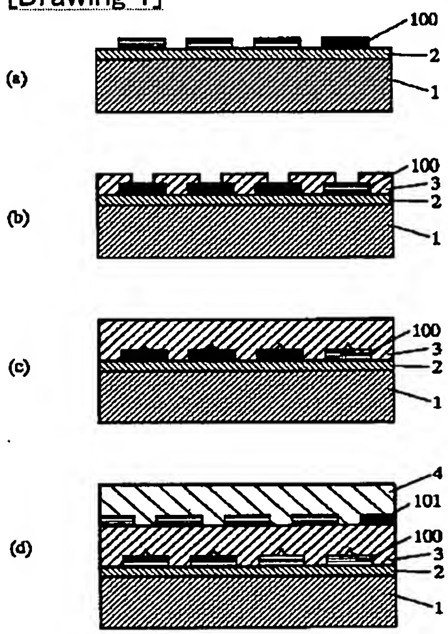
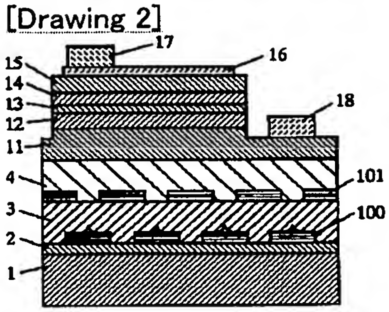
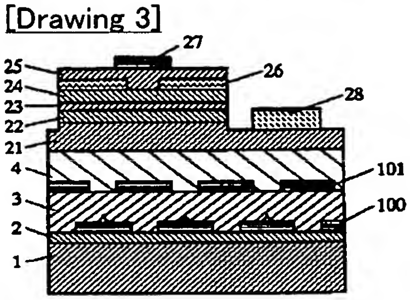
[Drawing 1]



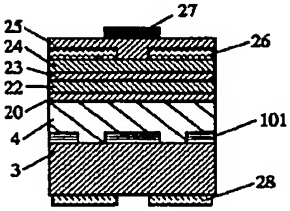

[Drawing 2]




[Drawing 3]




[Drawing 4]

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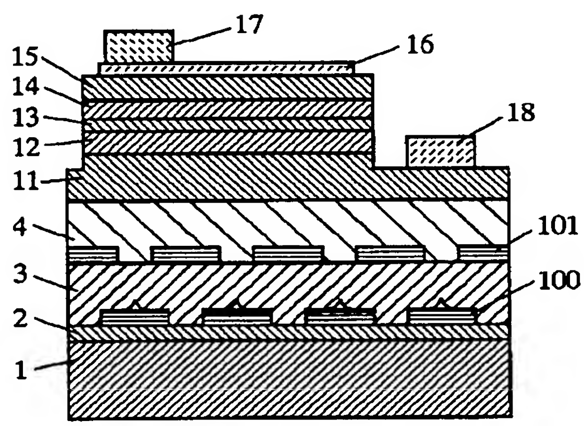
(54)【発明の名称】　窒化物半導体発光素子

(57)【要約】

【目的】　主として基板側に漏れる光を有効に反射させて、発光素子の光取り出し効率を向上させることにあり、また半導体層内部に共振器となる有効な反射鏡を有するレーザ素子を実現することにある。

【構成】　窒化物半導体と異なる材料よりなる異種基板上に形成された第１の窒化物半導体よりなる下地層の上に、表面に窒化物半導体が成長しないか若しくは成長しにくい性質を有し、かつ活性層の発光を反射する第１の反射鏡が部分的に形成されており、さらにその第１の反射鏡の窓部から、その反射鏡の表面に至るように成長された第２の窒化物半導体を基板として、その基板の上に少なくとも活性層を含む複数の窒化物半導体層が積層されいることにより、第１の反射鏡で活性層の発光を上方に反射させる。



【特許請求の範囲】

【請求項１】　窒化物半導体と異なる材料よりなる異種基板上に形成された第１の窒化物半導体よりなる下地層の上に、表面に窒化物半導体が成長しないか若しくは成長しにくい性質を有し、かつ活性層の発光を反射する第１の反射鏡が部分的に形成されており、さらにその第１の反射鏡の窓部から、その反射鏡の表面に至るように成長された第２の窒化物半導体を基板として、その基板の上に少なくとも活性層を含む複数の窒化物半導体層が積層されてなることを特徴とする窒化物半導体発光素子。

【請求項２】　前記第２の窒化物半導体層の上に第２の反射鏡が部分的に形成され、その第２の反射鏡の窓部から、第２の反射鏡の表面に至るように成長された第３の窒化物半導体を基板として、その基板の上に少なくとも活性層を含む複数の窒化物半導体層が成長されてなることを特徴とする請求項１に記載の窒化物半導体発光素子。

【請求項３】　前記第２の反射鏡は、第１の反射鏡の窓部の位置に対応した第２の窒化物半導体層の上に形成されていることを特徴とする請求項２に記載の窒化物半導体発光素子。

【請求項４】　前記反射鏡の面積が、窓部の面積よりも大きいことを特徴とする請求項１に記載の窒化物半導体発光素子。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は発光ダイオード（ＬＥＤ）、レーザダイオード（ＬＤ）、スーパールミネッセントダイオード（ＳＬＤ）等に使用される窒化物半導体（$In_aAl_bGa_{1-a-b}N$、$0\leqq a$、$0\leqq b$、$a+b\leqq 1$）よりなる発光素子に関する。

【０００２】

【従来の技術】窒化物半導体は青色ＬＥＤ、緑色ＬＥＤとして既に実用化されている。これらＬＥＤはサファイア基板上にｎ型、ｐ型の窒化物半導体が積層されたダブルヘテロ構造を有し、活性層は量子井戸構造の窒化物半導体層を有している。ＬＥＤを構成する窒化物半導体発光素子は、このサファイア基板側を発光観測面側とする場合と、窒化物半導体層側を発光観測面側とする場合の２種類の態様に分けられる。一般に窒化物半導体は正と負の電極が同一面側に設けられているため、サファイア基板側を発光観測面とした場合、例えばリードフレームのような支持体に電極を接続する際に、チップサイズが大きくなり、ハンドリング性も悪くなる欠点があるが、透明なサファイアの性質を積極的に利用しているので、光取り出し効率が良くなるという利点がある。一方、窒化物半導体側を発光観測面とする場合、チップサイズも小さくすることができ、ハンドリング性も前者の場合に比べて非常に優れているが、サファイア基板側に漏れる光は、例えばリードフレームの接着剤に吸収されて光取り出し効率が悪くなるという欠点がある。一般に市販されているＬＥＤは、ハンドリング性の良い後者の方が選択されている。

【０００３】

【発明が解決しようとする課題】後者の場合、サファイア基板側に漏れる光を反射させるために、サファイア基板表面に光反射膜を形成する技術も提案されているが、この技術では未だ十分満足できるものではなかった。また、面発光レーザ素子のような半導体層内部に反射鏡を形成する技術において、サファイア基板側に反射鏡を設けると活性層との距離が大きすぎて、反射鏡を共振器とするのが難しい傾向にある。

【０００４】本発明はこのような事情を鑑みてなされたものであって、その目的とするところは、主として基板側に漏れる光を有効に反射させて、発光素子の光取り出し効率を向上させることにあり、また半導体層内部に共振器となる有効な反射鏡を有するレーザ素子を実現することにある。

【０００５】

【課題を解決するための手段】本発明の発光素子は、窒化物半導体と異なる材料よりなる異種基板上に形成された第１の窒化物半導体よりなる下地層の上に、表面に窒化物半導体が成長しないか若しくは成長しにくい性質を有し、かつ活性層の発光を反射する第１の反射鏡が部分的に形成されており、さらにその第１の反射鏡の窓部から、その反射鏡の表面に至るように成長された第２の窒化物半導体を基板として、その基板の上に少なくとも活性層を含む複数の窒化物半導体層が積層されてなることを特徴とする。

【０００６】さらに、本発明の発光素子は、前記第２の窒化物半導体層の上に第２の反射鏡が部分的に形成され、その第２の反射鏡の窓部から、第２の反射鏡の表面に至るように成長された第３の窒化物半導体を基板として、その基板の上に少なくとも活性層を含む複数の窒化物半導体層が成長されてなることを特徴とする。

【０００７】前記第２の反射鏡は、第１の反射鏡の窓部の位置に対応した第２の窒化物半導体層の上に形成されていることが望ましい。なお、本発明において、異種基板、第１の反射鏡、下地層、第２の窒化物半導体より上の活性層を含む窒化物半導体層と第２の窒化物半導体とは必ずしも接して形成されている必要はなく、例えば窒化物半導体と異なる材料よりなる半導体層を、それらの間に成長させても良い。

【０００８】また本発明の発光素子では、前記反射鏡の面積が、窓部の面積よりも大きいことを特徴とする。

【０００９】

【発明の実施の形態】図１は、本発明の発光素子において、異種基板から第２の窒化物半導体層を成長させるまでの各工程において得られる窒化物半導体ウェーハの構造を示す模式的な断面図である。

【００１０】第２の窒化物半導体３よりなる基板を成長させるには、まず図１（ａ）に示すように、異種基板１の上に第１の窒化物半導体よりなる下地層２を成長させ、その下地層２の上に第１の反射鏡１００を部分的に形成する。異種基板１は従来より提案されている窒化物半導体と異なる材料よりなり、その表面に例えばバッファ層を介して窒化物半導体が成長できる材料が選択される。その中でも、実用化されているサファイアの他、スピネル（$MgAl_2O_4$）、ＺｎＯ、ＧａＡｓ、Ｓｉ、ＳｉＣ、窒化物半導体と格子整合する酸化物系基板等が提案されている。

【００１１】下地層２は、例えば２００℃～９００℃の低温において、$Al_xGa_{1-x}N$（$0 \leq X \leq 1$）よりなるバッファ層を介して、そのバッファ層よりも高温で窒化物半導体を成長させることによって成長できる。本発明では、バッファ層を含めた窒化物半導体を含んで下地層という。つまり、下地層は複数の窒化物半導体層から成っていても良い。但し、下地層は異種基板の上に成長されるため、異種基板と下地層との熱膨張係数差、格子不整合等の要因により結晶欠陥が非常に多く、例えば貫通転位が$10^9$個／cm²以上あり、窒化物半導体基板とならない。最も好ましい下地層としてはアンドープ若しくはｎ型不純物濃度が$1 \times 10^{17}$／cm³以下のＧａＮをバッファ層を介して成長させる。なお、下地層と異種基板との間に例えばＺｎＯ等の窒化物半導体と異なる半導体よりなるバッファ層を成長させることもできる。

【００１２】下地層２の上に形成する第１の反射鏡１００は、活性層の発光を上部に反射させる作用を有すると共に、反射鏡の窓部から反射鏡の表面に至るように横方向に成長する第２の窒化物半導体層の結晶欠陥を少なくする作用を有する。反射鏡は、例えばストライプ状、ドット状、碁盤目状等、下地層の上に部分的に形成すればどのような形状でも良いが、好ましくはストライプ状に形成する。反射鏡の材料としては、窒化物半導体がその反射鏡の表面に成長しないか若しくは成長しにくい性質を有する材料で、活性層の発光を活性層側に反射させる材料であれば、どのような材料でも良く、例えば$SiO_2$、ＳｉｘＮｙ、$TiO_2$、ＴｉｘＮｙ、$ZrO_2$等の誘電体より成る多層膜が選択できる。これら誘電体を例えばλ／４ｎ（λ：発光波長、ｎ：誘電体の屈折率）となるように積層することにより反射鏡として作用する。またＰｔ、Ｎｉ、Ｃｒ、Ａｇ等のように、例えば銀白色の金属で活性層の発光を反射して、表面に窒化物半導体が成長しにくい性質を有する金属でもよい。なお、反射鏡は、誘電体多層膜、金属等が第２の窒化物半導体の成長温度に耐える融点を有している材料を選択することが望ましい。

【００１３】第１の反射鏡１００は図１に示すように異種基板１の上に成長した第１の窒化物半導体よりなる下地層の上に形成されているが、異種基板１の上に直接形成することもできる。例えば異種基板１にサファイアを使用した場合には、サファイアの上に第１の窒化物半導体２を成長させることが、より結晶欠陥の少ない第２の窒化物半導体３を成長させる上で望ましい。一方、基板に窒化物半導体と格子整合した基板、格子定数の近い基板を用いる場合には、第１の反射鏡１００を直接、異種基板に接して形成することも可能である。



【００１４】次に図１（ｂ）に示すように第２の窒化物半導体３を、前記反射鏡を形成した下地層の窓部から成長させる。反射鏡１００は表面に窒化物半導体が成長しにくい性質を有しているため、第２の窒化物半導体３は窓部から成長しだし、（ｂ）に示すように、第１の反射鏡１００の上部では横方向に成長する。さらに成長を続けると、図１（ｃ）に示すように、横方向及び縦方向に成長する第２の窒化物半導体がおよそ反射鏡中央部の上部で繋がって、窒化物半導体基板となる。このように第２の窒化物半導体３を成長させると、下地層２の結晶欠陥が反射鏡で覆われていることにより、横方向に成長する第２の窒化物半導体の結晶欠陥は、下地層から伸びてこなくなる。また窓部から伸びてくる結晶欠陥が第２の窒化物半導体層の途中で止まるため、第２の窒化物半導体層成長後、表面に現れる結晶欠陥は非常に少なくなり、例えば$10^8$個／cm²以下、さらには$10^7$個／cm²以下になる。第２の窒化物半導体３は、アンドープ若しくはｎ型不純物濃度が$1 \times 10^{17}$／cm³以下のＧａＮを成長させることが結晶性の良い基板を作製する上で最も好ましい。

【００１５】さらに好ましい態様として、図１（ｄ）に示すように、第２の窒化物半導体層の上に、さらに第１の反射鏡と同様に第２の反射鏡１０１を形成し、この第２の反射鏡１０１の上部に、第３の窒化物半導体層４を同様にして成長させる。第２の反射鏡１０１を形成することにより、その第２の反射鏡の上部に成長させる第３の窒化物半導体４の結晶欠陥がさらに少なくなる。それは下地となる第２の窒化物半導体層３の結晶欠陥が少ないからである。好ましくは（ｄ）に示すように、第２の反射鏡１０１の位置を、第１の反射鏡の窓部に対応した第２の窒化物半導体層３の表面に形成することにより、窒化物半導体層側から平面的に見て、全てが反射鏡で覆われた形となるため、光取り出し効率がさらに向上する。また例えば第２の窒化物半導体３の結晶欠陥が窓部に現れている場合には、その窓部を第２の反射鏡でさらに覆うため、第２の反射鏡の上に横方向に成長される第３の窒化物半導体層の結晶欠陥がさらに少なくなる。即ち第２の反射鏡１０１は結晶欠陥が表面に現れている第１の窒化物半導体層３の上に形成することが最も好ましい。但し、第３の反射鏡はランダムに形成してもよい。

【００１６】本発明の反射鏡の作用は次の通りである。反射鏡の窓部から成長されて、反射鏡の表面で横方向に成長された窒化物半導体層は結晶欠陥が非常に少ない。

そのため、その窒化物半導体を基板とすることにより、その基板の上に成長させる活性層を含む複数の窒化物半導体層の結晶欠陥が窒化物半導体基板と同じように少なくなる。従って、発光素子を作製した際には、活性層に結晶欠陥が転位しないため、素子が長寿命となる。また逆方向の耐圧、リーク電流の電流特性等全ての面において向上する。しかも、反射鏡は活性層の発光を活性層側に反射させる作用もあるため、基板側に漏れる光が少なくなって、半導体側を発光観測面とする発光素子では光取り出し効率が向上する。そのため、窓部の面積よりも反射鏡の面積を大きくすることにより、反射部が大きくなって光取り出し効率が向上すると共に、窓部から伸びる結晶欠陥の数も少なくなり、さらに好ましい発光素子が実現できる。好ましくは先にも述べたように、反射鏡を縦方向に二段階以上に並べることにより、平面上では反射鏡が実質的に全ての面を覆った形となるため、光取り出し効率はさらに向上する。また、レーザ素子の場合には、第１の反射鏡１００若しくは第２の反射鏡１０１が半導体層内部にあり、活性層との距離が近い一方の共振器として作用するため、窒化物半導体で面発光レーザ素子が実現できる。

【００１７】

【実施例】［実施例１］図２は実施例１に係るＬＥＤ素子の構造を示す模式断面図である。以下この図を元に、実施例１を説明する。まず、サファイアよりなる異種基板１の上にＭＯＶＰＥ法を用いて、第１の窒化物半導体層２を成長させる。第１の窒化物半導体層２は異種基板側から順に、５００℃で成長されたＧａＮよりなるバッファ層と、バッファ層の上に１０５０℃で成長されたＧａＮからなる。

【００１８】次に反応容器からウェーハを取り出し、ＣＶＤ装置により、第１の窒化物半導体層２の全面に、$SiO_2$とＳｉＮよりなる誘電体多層膜を単一膜厚がλ／４ｎとなるように、交互に複数形成し、誘電体多層膜を形成する。

【００１９】誘電体多層膜形成後、その誘電体多層膜の上の所定の位置にマスクを形成して、その誘電体多層膜を選択エッチングして、ストライプ幅１０μｍ、ストライプ間隔（窓部）２μｍとし、第１の反射鏡１００とする。このような第１の反射鏡１００を誘電体多層膜で形成する際、最初に第１の窒化物半導体層の全面に誘電体多層膜を形成し、その後誘電体多層膜を選択エッチングして、所定の形状とする技術は、窒化物半導体層の上の所定の位置にマスクを形成して、その上から誘電体多層膜を形成して、その後リフトオフ法により、マスクを除去して誘電体多層膜のみを残す方法に比べて、均一な膜厚で誘電体多層膜が形成しやすい。また、窓部の窒化物半導体層表面もエッチングされるため、表面に現れているエッチピット、結晶欠陥等を観察しやすい。この手法の利点は、第２の反射鏡１０１の場合も同様である。

【００２０】次に第１の反射鏡１００を形成した後、ウェーハをＭＯＶＰＥ反応容器内に戻し、１０５０℃でアンドープＧａＮよりなる第２の窒化物半導体層３を２０μｍの膜厚で成長させる。

【００２１】第２の窒化物半導体層３成長後、ウェーハを反応容器から取り出し、再度ＣＶＤ装置にて、第２の窒化物半導体層３の全面に$SiO_2$とＳｉＮよりなる誘電体多層膜を形成した後、選択エッチングより、ストライプ幅１０μｍ、窓部２μｍとし、第２の反射鏡１０２とする。但し第２の反射鏡１０１の形成位置は、図２に示すように、第１の反射鏡１００と第２の反射鏡１０１のストライプが平行になるように形成して、平面から見て、第１の反射鏡１００の窓部が塞がるようにする。

【００２２】次に、ウェーハを反応容器内に戻し、１０５０℃でアンドープＧａＮよりなる第３の窒化物半導体層４を２０μｍの膜厚で成長させる。

【００２３】続いて、１０５０℃でＳｉドープしたｎ型ＧａＮよりなるｎ側コンタクト層１１を４μｍ成長させ、その上にＳｉ濃度がｎ側コンタクト層よりも少ないＧａＮよりなるｎ側クラッド層１２を０．１μｍ成長させる。

【００２４】次に８００℃で、膜厚３０オングストロームの単一量子井戸構造を有するアンドープ$In_{0.1}Ga_{0.9}N$よりなる活性層１３を成長させ、その上に１０５０℃でＭｇドープｐ型$Al_{0.1}Ga_{0.9}N$よりなるｐ側クラッド層１４を０．１μｍ成長させ、最後に、Ｍｇドープｐ型ＧａＮよりなるｐ側コンタクト層１５を０．５μｍ成長させる。

【００２５】反応終了後、ウェーハを反応容器から取り出し、窒素雰囲気中７００℃でアニーリングを行い、ｐ型層をさらに低抵抗化した後、図２に示すようにｐ側コンタクト層１５側からエッチングを行い、ｎ側コンタクト層１１の表面を露出させる。その後、最上層のｐ側コンタクト層の表面のほぼ全面に透光性のオーミック用のｐ電極１６を形成し、その上にボンディング用のｐパッド電極１７を形成する。一方、先ほど露出させたｎ側コンタクト層１８の表面には、Ｗ／Ａｌよりなるｎ電極１８を形成する。

【００２６】最後に、サファイア基板を研磨して薄くした後、３５０μｍ角のチップに分離して青色ＬＥＤ素子としたところ、反射鏡を設けない従来のＬＥＤ素子に比較して、出力で５０％以上向上し、素子寿命で数倍以上に向上した。また逆方向の耐圧も従来のものに比較して、５０％以上向上した。これは第２、第３の窒化物半導体が基板となっているために、素子自体の結晶欠陥が少なくなり、逆方向の耐圧、素子寿命が向上したものと推察できる。

【００２７】［実施例２］図３は本発明の実施例２に係るＬＤ素子の構造を示す模式断面図であり、具体的には面発光レーザ素子の構造を示している。以下この図を元

に、実施例２を説明する。

【００２８】実施例１と同様にして、サファイアよりなる異種基板１の上に、ＧａＮバッファ層、アンドープＧａＮよりなる第１の窒化物半導体層２、誘電体多層膜より成るストライプ状の第１の反射鏡１００、アンドープＧａＮよりなる第２の窒化物半導体層３、誘電体多層膜より成るストライプ状の第２の反射鏡１０１、アンドープＧａＮよりなる第３の窒化物半導体層４を順に積層させる。

【００２９】続いて、Ｓｉドープn型ＧａＮよりなるn側コンタクト層２１を４μm成長させた後、膜厚２５オングストロームのアンドープ$Al_{0.15}Ga_{0.85}N$層と、膜厚２５オングストロームのＳｉドープＧａＮ層とを交互に積層して、総膜厚０．４μmの超格子より成るn側クラッド層２２を成長させる。

【００３０】次に、４０オングストロームのアンドープ$In_{0.01}Ga_{0.99}N$よりなる障壁層と４０オングストロームのアンドープ$In_{0.2}Ga_{0.8}N$よりなる井戸層とを交互に積層し、最後に障壁層で終わり、総膜厚４４０オングストロームの多重量子井戸構造（ＭＱＷ）の活性層２３を成長させる。

【００３１】次に、２５オングストロームのアンドープ$Al_{0.15}Ga_{0.85}N$層と、２５オングストロームのＭｇドープＧａＮ層とを交互に積層して、総膜厚０．４μmの超格子層よりなるｐ側クラッド層２４を成長させる。

【００３２】ｐ側クラッド層成長後、ウェーハを反応容器から取り出し、円形を有する$SiO_2$よりなる保護膜をそのｐ型クラッド層の表面に形成する。但し、そのマスクの位置は前記第２の反射鏡１０１よりも小さく、その反射鏡の真上になるように形成する。

【００３３】保護膜形成後、再度、ウェーハを反応容器内に移し、その保護膜が形成されていないｐ側クラッド層２４の表面にＳｉドープn型$Al_{0.1}Ga_{0.9}N$よりなる電流阻止層２６を０．４μmの膜厚で形成する。なおこの電流阻止層はＺｎ、Ｃｄのようなｐ型不純物をドープしてもｐ型になりにくいｐ型不純物をドープして、高抵抗なｉ型の窒化物半導体層としてもよいし、またＡｌ混晶比をクラッド層よりも大きくして高抵抗なｉ型ＡｌＧａＮを形成することもできる。

【００３４】電流阻止層２６形成後、ウェーハを反応容器から取り出し、保護膜を溶解除去した後、再び反応容器内において、その電流阻止層２６の上にＭｇドープｐ型ＧａＮよりなるｐ側コンタクト層２５を成長させる。

【００３５】反応終了後、アニーリングを行いｐ層をさらに低抵抗化し、実施例１と同じく、エッチングによりn側コンタクト層２２の一部を露出させ、露出したn側コンタクト層２２にn電極２８を形成する一方、ｐ側コンタクト層の表面にｐ電極２７を形成した後、ウェーハをチップに分離して図３に示すような構造のレーザ素子としたところ、室温において連続発振を示し、４１０nmのレーザ光がサファイア基板側から観測された。

【００３６】［実施例３］図４は本発明の実施例３に係るＬＤ素子の構造を示す模式断面図であり、これもまた面発光レーザ素子の構造を示している。以下この図を元に、実施例３を説明する。

【００３７】実施例１において、サファイアよりなる異種基板１の上に、ＧａＮバッファ層、アンドープＧａＮよりなる第１の窒化物半導体層２、誘電体多層膜より成るストライプ状の第１の反射鏡１００を形成した後、第２の窒化物半導体層３を成長させる際に、Ｓｉを$5\times10^{18}$／cm³ドープしたＧａＮを６０μmの膜厚で成長させる。この第２の窒化物半導体層の膜厚を６０μm以上にするのは、後に異種基板を除去して、第２の窒化物半導体層を基板とするためである。６０μmよりも薄いと、異種基板除去中に第２の窒化物半導体層が割れて、素子作製が難しくなる傾向にある。さらにn型不純物を少量ドープするのは、異種基板を除去した後に、露出される第２の窒化物半導体層３、そのものをコンタクト層とするからである。さらに基板となる第２の窒化物半導体層、第３の窒化物半導体層にn型不純物をドープする場合、先にも述べたように$1\times10^{17}$／cm³以下とすることが望ましい。それよりも多くすると窒化物半導体層中の結晶欠陥の数が多くなって、結晶性の良い基板となりにくいからである。

【００３８】第２の窒化物半導体層３成長後、実施例１と同様にして、第２の反射鏡１０１を形成する。第２の反射鏡形成後、アンドープＧａＮよりなる第３の窒化物半導体層４を１５μm成長させる。

【００３９】次にＳｉをドープした$In_{0.05}Ga_{0.95}N$より成るクラック防止層２０を０．１５μmの膜厚で成長させる。クラック防止層２０はＩｎを含む窒化物半導体とすることにより、この層が緩衝層となり、後に成長させるＡｌを含む窒化物半導体層にクラックが入りにくくなる。なお、このクラック防止層は実施例２のレーザ素子に入れても良いことは言うまでもない。

【００４０】あとは実施例２と同様にして、超格子よりなるn側クラッド層２２、ＭＱＷの活性層２３、超格子よりなるｐ側クラッド層２４、電流阻止層２６、ｐ側コンタクト層２５を積層する。

【００４１】反応終了後、アニーリングを行いｐ層をさらに低抵抗化した後、サファイア側から研磨して、異種基板１、第１の窒化物半導体層２、第１の反射鏡１０１を除去する。その後、露出させた第２の窒化物半導体層２の表面にリング状のn電極を設けた後、ウェーハをチップ状に分離して、図４に示すような構造のレーザ素子としたところ、室温において連続発振を示し、同じく４１０nmのレーザ光が第２の窒化物半導体層３側から観測された。なおn電極２８を形成する際に、電極接触面のオーミックコンタクトを良くするために、イオンインプランテーション等の技術を用いて、第２の窒化物半導

体層の表面にｎ型不純物を高濃度にドープしても良い。

【００４２】

【発明の効果】以上説明したように、本発明の発光素子では、反射鏡の窓部から成長されて、反射鏡の表面で横方向に成長された窒化物半導体層の結晶欠陥が非常に少なくなるために、その基板の上に成長させる活性層を含む複数の窒化物半導体層の結晶欠陥が少なくなり、素子の信頼性が向上する。また、反射鏡が活性層の発光を数十μm以下という近い距離において、活性層側に反射させるので、発光素子の光取り出し効率が向上する。そのため、この反射鏡を積極的に利用すれば、面発光レーザ素子が実現できる。

【図面の簡単な説明】

【図１】　本発明の発光素子を製造する際の各工程を説明するためのウェーハの構造をそれぞれ部分的に示す模式断面図。

【図２】　実施例１の発光素子の構造を示す模式断面図。

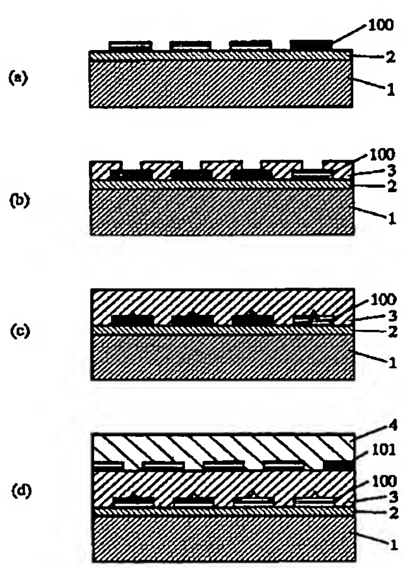
【図３】　実施例２の発光素子の構造を示す模式断面図。

【図４】　実施例３の発光素子の構造を示す模式断面図。

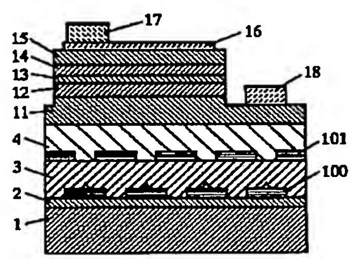
【符号の説明】

１・・・異種基板
２・・・第１の窒化物半導体層
３・・・第２の窒化物半導体層
４・・・第３の窒化物半導体層
１１,２１・・・ｎ側コンタクト層
１２,２２・・・ｎ側クラッド層
１３,２３・・・活性層
１４,２４・・・ｐ側クラッド層
１５,２５・・・ｐ側コンタクト層
２０・・・クラック防止層
２６・・・電流阻止層
１６,２７・・・ｐ電極
１７・・・ｐパッド電極
１８,２８・・・ｎ電極
１００・・・第１の反射鏡
１０１・・・第２の反射鏡

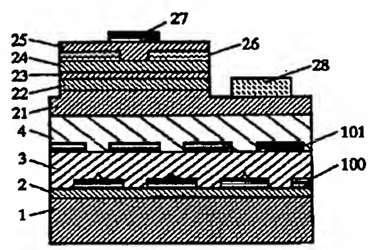
【図１】




【図２】




【図３】




【図４】